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(56) Documents Cited
GB 2037268 A GB 1600901 A GB 1560467 A
GB 1123833 A GB 0305346 A EP 0283153 A1
US 5043081 A US 5013458 A US 4997572 A

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(54) Process for treatment of sewage sludge

(57) Sewage sludge is treated with cement kiln dust or other lime-containing material in order to achieve a pH in the mixture of at least 10 but preferably less than 12, the resultant mixture being dried, and preferably composted, in order to obtain a granular material suitable for application to land. Preferably, the mixture is composted such that the temperature is maintained at 40°C or above for at least 5 days, with a temperature of at least 55°C being achieved for at least 4 hours within that period.

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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

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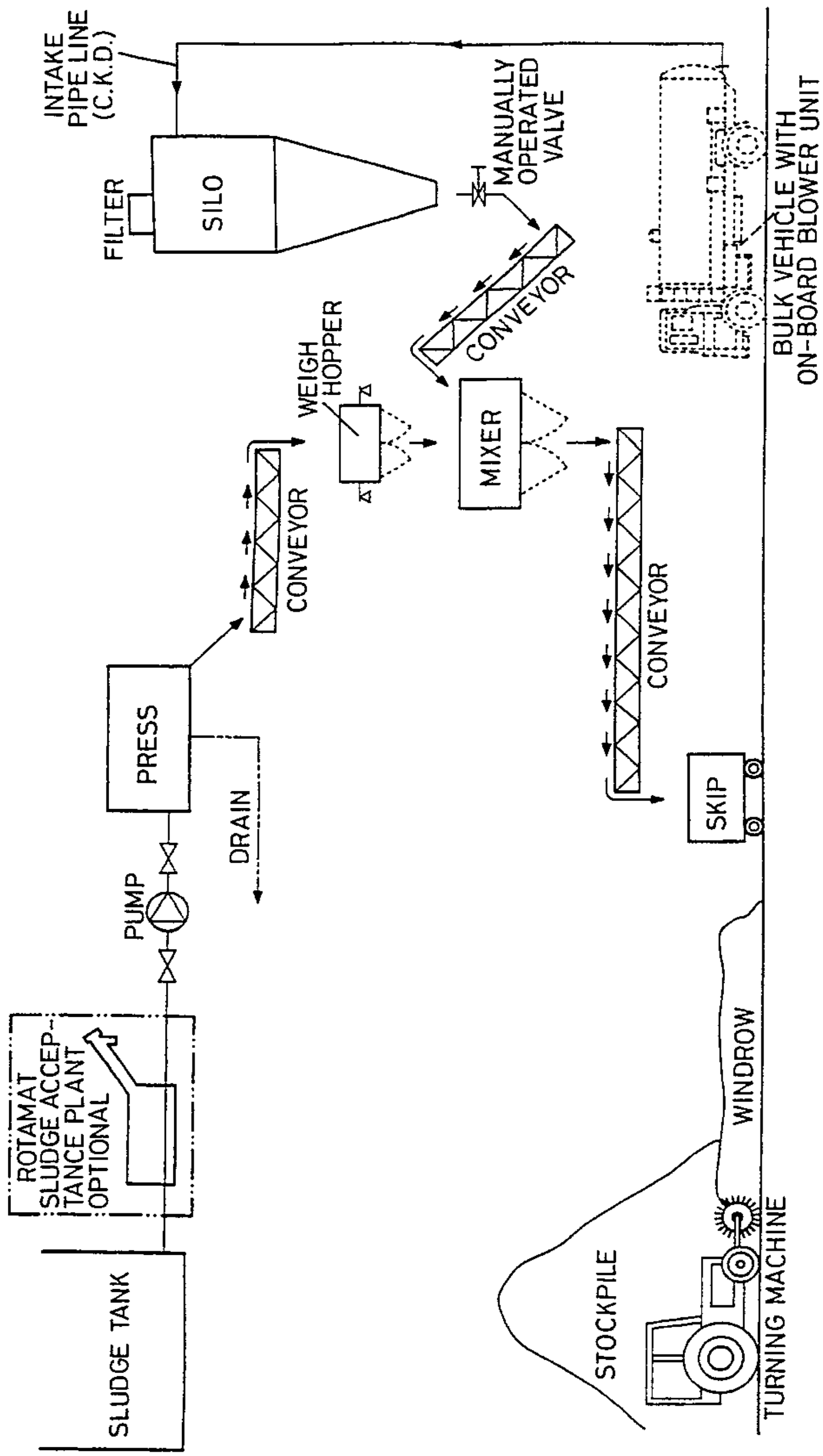
INTAKE PIPE LINE (C.K.D.)
FILTER
SILO
MANUALLY OPERATED VALVE
CONVEYOR
BULK VEHICLE WITH ON-BOARD BLOWER UNIT
WEIGH HOPPER
MIXER
CONVEYOR
CONVEYOR
PRESS
DRAIN
SKIP
PUMP
ROTAMAT SLUDGE ACCEPTANCE PLANT OPTIONAL
SLUDGE TANK
WINDROW
STOCKPILE
TURNING MACHINE

FIG. 1

2/2

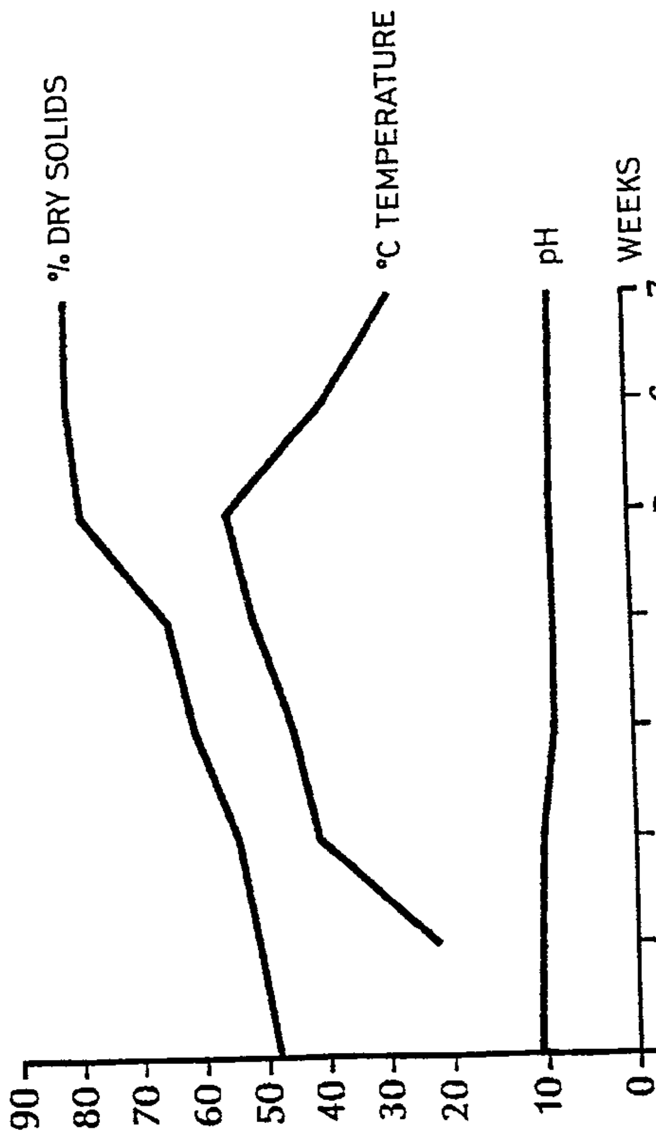
% DRY SOLIDS
°C TEMPERATURE
pH
WEEKS
90
80
70
60
50
40
30
20
10
0
0
1
2
3
4
5
6
7

FIG. 2

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Process for Treatment of Sewage Sludge

Field of the Invention

The present invention relates to a process for treating sewage sludge, in particular a process for converting sewage sludge into a material that can be used as a soil-conditioning agent and/or as a fertiliser.

Background to the Invention

Sewage sludge may be obtained at various stages of the treatment of sewage, in particular municipal sewage, and includes primary sludge from a preliminary settlement process, secondary sludge from an aeration process, e.g. activated sludge, humus sludge from naturally or forcibly aspirated filter beds, sludge obtained from a mesophilic or thermophilic digestion process, and mixtures comprising two or more of such sludges. In an unprocessed state, sewage sludge is typically a malodorous material that contains pathogens and which attracts disease vectors such as flies and rodents; the safe disposal of sewage sludge, which is produced in large quantities, is therefore a considerable problem. However, it is potentially useful as a soil-conditioning agent having some fertilising capability and there is, accordingly, considerable interest in processes that can render sewage sludge fit for application to the land.

EP-A-0,283,153 discloses a method of treating waste-water sludge to provide a fertiliser, which method comprises the steps of (i) mixing the sludge with at least one alkaline material, in particular lime, cement kiln dust or lime kiln dust, to form a mixture, the amount of alkaline material being sufficient to raise the pH of the mixture to at least 12 for a predetermined period of time, in particular for a period of at least one day, and preferably for at least seven days, and (ii) drying the mixture, preferably for at least 30 days and until a solids concentration of at least 65% solids is reached.

Summary of the Invention

The present invention provides a process for the treatment of sewage sludge, which comprises the steps of mixing sewage sludge having a solids content of at least 15% by weight with an alkaline material (which expression includes basic or alkaline-reacting materials) containing free lime, especially calcium oxide, and storing and/or drying and/or composting the resultant mixture, characterised in that the amount of lime added to the sewage sludge is sufficient to achieve a pH in the mixture of at least 10.

Brief Description of the Drawings

Figure 1 is a schematic flow-chart of a preferred embodiment of the present process for treating sewage sludge.

Figure 2 is a graph showing the variation with time (in weeks) of the pH, temperature (°C) and dry-solids content (% by weight) of sludge treated in an exemplary embodiment of the present invention.

Description of Exemplary Embodiments

The sewage sludge is typically obtained from one or more of the sources mentioned above in connection with the background to the invention. However, the term "sewage sludge" herein is to be construed broadly, to include not only waste-water sludges but also septic tank pumpings. Although the sewage sludge to which the alkaline material is added may have a solids content as low as 15% by weight, it is preferred that the solids content be at least 20% by weight, more preferably at least 30% by weight. Normally, the solids content of the sewage sludge to be treated will not exceed 45% by weight and is preferably not more than 40% by weight, a typical content being about 35% by weight.

The raw sewage sludge as supplied to the treatment plant may have a low dry solids content, typically 6 to 7% by weight down to (e.g. in the case of activated sludge) 1 to 2% by weight. The desired solids content may be

achieved, if required, by subjecting the raw sewage sludge to a dewatering process, for example in a plate filter, belt press or centrifuge. The dewatered material may also be referred to herein as "(sewage) sludge cake". Before it is dewatered, the sludge is generally treated with a conditioning agent; thus, one or more flocculating agents, for example any of the polymeric flocculants (polyelectrolytes) known in the art, may be added to the sewage sludge in order to facilitate the dewatering process; inorganic flocculants are also known, e.g. a lime/ferric chloride mixture. Prior to such conditioning, the sludge is generally screened in order to remove coarse solids (including plastics and rags) or is derived from sewage that has been either macerated or subjected to fine screening. The pH of the dewatered sewage sludge is typically from 6.8 to 7.2, though it may be lower (e.g. when the sludge has a considerable industrial effluent component) or higher (e.g. when lime has been used as a conditioning agent).

The alkaline material with which the dewatered sludge is treated preferably contains free quicklime (i.e. calcium oxide, CaO) as this not only raises the pH but also reacts with water exothermically and thereby raises the temperature and reduces the free water content of the sludge. Slaked lime (calcium hydroxide, $Ca(OH)_2$) is much less preferred. Suitable alkaline materials containing free calcium oxide include cement kiln dust, lime kiln dust, pulverised fly ash (which is obtainable from power stations), ground dolomitic limestone with an addition of quicklime, or a mixture thereof. It is particularly preferred to use cement kiln dust. The free lime content of cement kiln dust can, exceptionally, be as high as 30% by weight and may be as low as 1% but the normal range for the free lime content is from 3% to 15%, e.g. up to 10%, typically 6% to 8%, by weight. In addition to lime, cement kiln dust generally also contains potassium, sulfur and phosphorus, which add to the fertilising value of sludge treated with it. A typical oxide composition range for cement kiln dust containing 1-10% free CaO is 11-16% SiO_2, 3-6% Al_2O_3, 1-4% Fe_2O_3, 34-49%

CaO, 0-2% MgO, 4-18% SO_3, 3-13% K_2O, 0-2% Na_2O, 0-5% Cl and 11-25% loss on ignition. In cases where the available cement kiln dust is low in free lime, additional alkaline material, preferably quicklime, may be added in order to achieve the required pH value in the treated sewage sludge; this may be useful where the moisture content of the dewatered sludge or sludge cake is not high enough to accommodate the large amount of low-lime cement kiln dust that would be necessary to achieve the desired pH. The cement kiln dust is admixed to the sewage sludge in an amount sufficient to achieve a pH of at least 10, preferably at least 10.5, more preferably at least 10.8 and most preferably 11 or higher. Preferably, the pH is kept below 12.0, more preferably below 11.8 and most preferably below 11.5. Surprisingly, it has been found that an excellent reduction in pathogens can be achieved at pH levels below 12, especially when a pH of at least 10.5, preferably at least 10.8, and more preferably at least 11, is maintained for at least 7 days. Below pH 12, the evolution of ammonia is reduced considerably, thereby rendering the treated sludge and its surroundings less unpleasant. Moreover, the reduction in loss of ammonia means that the treated material retains more of its nitrogen value and hence renders the material more useful as a fertiliser.

As a guide, it usually requires a content of from 2% to 5%, typically 2.5% to 3.0%, by weight of free CaO on a dry basis within the mixture of sewage sludge and alkaline material, e.g. cement kiln dust, to achieve a pH of from 10 to 12. It is normally possible to measure the pH of the mixture to one decimal place.

The lime-containing treating material should be in the form of fine granules, a powder or other finely divided state for best effect. Particle-size characteristics for certain preferred kiln dusts are disclosed in EP-A-283,153 (the teaching in which is incorporated herein by reference). Other preferred materials are characterised by a particle grading of at least 80% finer than 100μm. Another preferred characterisation of suitable materials is a particle grading

of 25-55%, preferably 40-50%, finer than 5μm and 15-40%, preferably 25-35%, finer than 2μm.

It is important that the alkaline material (e.g. the cement kiln dust and, if used, any supplementary alkali) should be thoroughly mixed with the sewage sludge to ensure that there are no untreated regions within the mass of sewage sludge that might later give rise to regrowth of pathogenic organisms. It has been found that excellent blending of the sewage sludge and the alkaline material may be accomplished by batch blending methods. A paddle mixer is preferred, e.g. of the type used in the food industry, and a favoured mixer is of the type disclosed in GB-A-2,026,881 (the teaching in which is incorporated herein by reference). The use of an auger to break up lumps is also recommended. In general, the dry solids content and the pH of the sludge to be treated are determined and the cement kiln dust, or other lime-containing alkaline treating material, is metered in automatically, if appropriate with supplementary alkaline material. Typically, the weight ratio of cement kiln dust to sewage sludge solids is from 0.5:1 to 2.0:1 (although variations are, of course, possible, depending of the pH of the dewatered sludge, the intended pH of the treated mixture and the lime content of the cement kiln dust). Thus, if the amount of cement kiln dust is about 35% by weight of the sewage sludge and the sewage sludge has a solids content of about 35%, the ratio of cement kiln dust to sewage sludge solids is approximately 1:1 by weight. As indicated above, the process of adding the cement kiln dust, or other lime-containing basic treating material, to the sewage sludge not only raises the pH of the latter but also gives rise to an increase in temperature owing to the reaction of the calcium oxide with the water in the sewage sludge. This generally results in a reduction in pathogens and hence the treatment of the sludge with the lime-containing material may be regarded as a disinfection step; however, this is not to imply that this step necessarily results in a total kill of pathogens.

The resultant mixture ("cake mix") of sludge cake and

cement kiln dust, or other lime-containing alkaline treating material, is generally a granular material, typically having a solids content of about 30% to about 50% by weight, which may be readily handled for subsequent processing.

Provided that the amount of calcium oxide that has been introduced is sufficient to raise the pH to a value greater than 12, and provided that it is sufficient to ensure that the pH is not less than 12 for a minimum period of two hours, it is possible simply to store the granular cake mix for a period of not less than 2 hours before the product is applied to land. Such a process is in accordance with the United Kingdom Department of the Environment's current Code of Practice. The product is granular and generally has a dry solids content of 40-50% by weight. It is easily stored and applied and is initially free from malodour and pathogenic organisms. However, it is not sterile and if stored for more than 2 or 3 weeks, there may be a resumption of biological activity resulting in some malodour.

A product having a longer storage capability may be obtained by subjecting the cake mix to a drying process and/or to a composting process. Drying is preferably carried out by windrowing the cake mix, that is to say forming the material into piles which are periodically, and as required, turned and aerated, normally for a period of up to 7 days, typically for 3 to 4 days. When windrowing the material to reduce the moisture content by air-drying, it is recommended that the product be protected from rainfall. Furthermore, the action of windrowing helps to reduce the particle size and also promotes good granulation. The windrowing or other drying process should result in a temperature within the mass of at least 40°C, but preferably not higher than 50°C, being achieved. The windrowing can be controlled to produce either of two distinct products. For the first, the turning is frequent such that the dry solids content is raised to 65% by weight or higher. For the second, the turning is less frequent such that the dry solids content is less than 65% but preferably at least 40%,

more preferably at least 55% and most preferably about 60% by weight. Drying methods other than windrowing do, of course, also come into consideration, especially such methods as permit the aforesaid solids content to be achieved.

The second product (solids content < 65% by weight) is generally then allowed to compost; usually composting will not proceed until the pH has fallen to about 9, which may take 1 to 2 weeks from the treatment with the lime-containing material. Windrowing may be continued in that interim period. Composting by windrowing is currently preferred. Composting should be carried out for a period of time, during which the temperature within the mass should be maintained at 40°C or higher for a period of at least 5 days and, for a period of at least 4 hours during that period, a temperature of 55°C or higher should be achieved within the body of the pile. Under such conditions, the above-described composting method is believed to comply with the requirements for composting processes according to the United Kingdom Department of the Environment's current Code of Practice and the regulations of the United States Environmental Protection Agency (EPA) for processes to significantly reduce pathogens (PSRP). It is possible to effect composting so that a temperature of 55°C is maintained for a period of at least 3 days, e.g. at least 15 days; the resultant composted material is believed to meet the U.S. EPA requirements for sludge treated according to processes for further reducing pathogens (PFRP).

Normally, the product is allowed to mature further, to ensure that the natural biological processes involved in composting are essentially complete. The composting phase may be regarded as complete when the temperature falls below 40°C and the dry solids content has risen to 70% by weight or higher. Since the treated sludge is a good heat insulator, and water is evaporated off at the elevated temperatures that are achieved, the water content may fall to a point where composting stops. However, it is possible to spray water onto the material when turning it so as to

prolong the composting phase.

The composted material is granular and can be stored for a considerable period in the open air without the development of malodours. Under normal conditions, rain water is shed from the surface and penetrates only a few centimetres from the exposed surface into the body of the piled material.

The composting procedure is especially beneficial when the sludge that has been disinfected by the alkaline treatment has an initial pH between 11 and 12, especially when a pH of at least 10.5 is maintained for a period of at least 7 days.

Variations are, of course, possible. For example, instead of windrow drying or composting methods, within-vessel or static aerated pile drying or composting methods may be employed.

Although it is conventional to add straw, wood shavings, sawdust, old newspapers or the like in order to support material to be composted and thereby facilitate the passage of air through the pile, it is an advantage of the present invention that the granular nature of the cake mix obtained in this invention allows such additives to be dispensed with.

As a further alternative to manual or mechanised windrowing, the sludge treated with the alkaline material may be dried in a rotating drum, e.g. in a conventional grain drum-dryer. The drying may be effected by passing in gas, e.g. air or carbon dioxide, at ambient temperature or higher. The use of a reactive gas such as carbon dioxide may itself raise the temperature of the sludge owing to the heat of reaction; it may be possible by this means to achieve a very efficient removal of pathogens by heating the sludge at about 70°C for a period as short as 12 minutes. The use of a rotating drum also comes into consideration for the composting step.

When aeration of the lime-treated sludge is effected, it is usual to use air, although the use of oxygen-enriched air or other gases is not precluded. It should be mentioned

that the treated sludge may be pelletized, if required, at any convenient stage of the process; for example, the cake mix may be pelletized before drying and/or composting.

The moisture content of the end product can be varied, according to need and according to the method by which the cake mix is processed. By way of example, at 40% by weight dry solids, the products have a comparatively short "shelf life" of 2 weeks to 2 months, whereas at 60% by weight dry solids, the shelf life is several months, even in the open air, and the granules are lighter and better formed, thereby rendering the product suitable for application not only by flail spreading but also by blowing through a rain gun or by means of a fertiliser spreader. The product of this invention may have solids contents as high as 80 to 85% by weight, if required.

The process of the present invention may be carried out so as to reduce significantly the content of viable pathogens (including animal viruses and pathogenic bacteria such as *Salmonella* sp.) and parasites (such as *Ascaris* sp., *Taenia saginata* and the potato cyst nematode). The attractiveness of the sewage sludge to disease vectors is reduced, as is the unpleasant smell; normally, the product has an acceptable smell reminiscent of freshly turned soil. The process also converts heavy metals present in the sludge into their insoluble hydroxides, thereby reducing their leachability and inhibiting their take-up by crops grown on land treated with the product of the present process. The product of this invention has a high organic content and is generally useful as a soil conditioner. The product also has a significant fertilising capability, owing to its content of N,P and K values. A wide variety of applications for the product come into consideration; for example, it may be spread to land and ploughed into areas intended for cereal crops, e.g barley; applied to the surface of grassland; applied in areas intended for silviculture; and used for land reclamation, landscaping and topsoil replacement, as well as for landfill covering.

The choice of post-disinfection treatments endows the

process of the present invention with the flexibility to make use of the various disposal routes that may be available at different times of the year. Thus, for example, during the spring when it is possible to get machinery onto the land easily, advantage can be taken of the short-term storage process with its reduced production costs. During the winter, when access to the land may be reduced, or in the summer when a stabilised granular product is required for the surface dressing of grassland, the fully composted product can be advantageously applied.

Example

Municipal sludge is treated in a plant illustrated schematically in Figure 1. The sludge is initially stored in a sludge tank, from which it is pumped, optionally via a Rotamat sludge-acceptance plant in which coarse solids are removed, to a filter press, in which the sludge is dewatered to a solids content of 35% by weight. The expressed water is drained away and the resultant sludge cake is conveyed by means of a worm conveyor to a weighing hopper, from which it is discharged batchwise into a paddle mixer (from Messrs. Tatham Forberg).

Cement kiln dust, which may be delivered in bulk by means of a road tanker having an on-board blower unit, is charged into a silo. The cement kiln dust is discharged via a manually operated valve from the silo to a worm conveyor, which delivers the cement kiln dust to the above-mentioned mixer in which it is thoroughly blended with the sludge cake, in an amount of 35% by weight of the sludge cake (thereby producing a mixture containing 50% by weight of cement kiln dust on a dry solids basis). With cement kiln dust having a free lime content of 8% by weight, the total quick lime dose in the mixture of cement kiln dust and sludge cake is about 2.8% by weight on a dry basis. A mixer of 60 litres' capacity is generally adequate to serve a population of ca. 25,000; typically, the shaft speed is within the range 60-100 r.p.m., the blending being generally effected for a period within the range of 10 to 60 seconds, depending on the consistency of the sludge.

The resultant mixture or cake mix, which has a pH of between 11 and 12, is then transferred to a skip by means of a worm conveyor. The skip is used to transport the cake mix to an area wherein the cake mix is air dried by windrowing. During windrowing, the cake mix is protected from heavy rainfall. The windrowing is carried out for 3-4 days and/or until the solids content reaches and is maintained at a level of at least 50% by weight. At that stage, the pH of the material is still alkaline, although further windrowing will reduce the pH. The rate of decline of the pH depends to a large extent upon the frequency of turning of the windrows, which turning is carried out by machine (e.g. a KS Compo (trade name) machine). The windrowed material is then composted and thereafter stockpiled until needed. The composting is also effected by machine windrowing; the conditions are such that a temperature of 40°C or above is maintained for a period of more than 3 weeks, with a temperature of at least 55°C being maintained for at least 4 hours within that period.

Typical variations in pH, dry solids (% by weight) and temperature (°C) are shown in Figure 2. The temperature reaches 40°C after 2 weeks from the treatment with cement kiln dust and peaks at 55°C after 5 weeks have elapsed.

Typically, the material so obtained contains 8.8 g/kg nitrogen, 5.1 g/kg phosphorus (as P_2O_5) and 12.8 g/kg potassium (as K_2O), on a dry weight basis. Typical values of the heavy metal content of the raw sludge and the finished product are given in Table 1 below.

The rate of destruction of coliform pathogens in dewatered sludge treated with cement kiln dust was determined in two pilot-scale tests. The results are recorded in Tables 2 and 3 below, the population of coliform bacteria being expressed in colony-forming units (cfu)/gwwt in logarithmic form (e.g. "4E+05" = $4x10^5$). The elapsed time is expressed in hours after the initial addition of cement kiln dust and the dry solids content (DS) is expressed in percent by weight. The values of the untreated sludge are indicated by "BM" (before mixing). The contents

of nitrogen (as N), phosphorus (as P_2O_5) and potassium (as K_2O) in the treated sludge are also recorded, as are the pH values of the sludge at various times. In both tests, the amount of cement kiln dust added was 30% by weight of the dewatered sludge. Comparison of the results in the Tables shows that the coliform destruction at pH 10.8 was comparable to that obtained at pH 12.1.

It will of course be understood that the present invention has been described above purely by way of example and that modifications of detail can be made within the scope of the invention.

Table 1

	Heavy Metal Content (mg/kg dry wt)	
	Raw Sludge	Product
Cd	1	1.7
Cr	22	31
Cu	142	72
Ni	20	32
Pb	77	153
Zn	565	251
Hg	4	2

Table 2

TIME (hrs)	COLI (cfu/gwwt)	N (g/kg)	P205 (g/kg)	K20 (g/kg)	%DS	pH
BM	4E+05				30	
1	2E+02	7.90	5.04	12.70	50	10.8
2	0E+00				50	10.8
3	0E+00				50	10.8
4	0E+00				50	10.8
8	0E+00				50	10.8
24	0E+00				50	10.8
48	0E+00				50	10.8

Table 3

TIME (hrs)	COLI (cfu/gwwt)	N (g/kg)	P2O5 (g/kg)	K2O (g/kg)	%DS	pH
BM	2E+07				24	
1	1E+03	6.20	4.24	12.40	47	12.1
2	1E+02				47	12.1
3	0E+00				47	12.1
4	0E+00				47	12.1
8	0E+00				47	12.1
24	0E+00				47	12.1
48	0E+00				47	12.1

CLAIMS

1. A process for the treatment of sewage sludge which comprises the steps of mixing sewage sludge having a solids content of at least 15% by weight with an alkaline material containing free lime, and storing and/or drying and/or composting the resultant mixture, characterised in that the amount of lime added to the sewage sludge is sufficient to achieve a pH in the mixture of at least 10.

2. A process according to claim 1, wherein the sewage sludge has a solids content of from 20 to 45% by weight, preferably from 30-40% by weight.

3. A process according to claim 1 or 2, wherein the sewage sludge is obtained by a process which comprises dewatering raw sewage sludge.

4. A process according to claim 1, 2 or 3, wherein the alkaline material contains free calcium oxide.

5. A process according to any of claims 1 to 4 wherein the alkaline material comprises cement kiln dust.

6. A process according to any of claims 1 to 5, wherein the lime is added in an amount sufficient to raise the pH to 11.0 or above but less than 12.

7. A process according to any of claims 1 to 6, wherein, in the second step, drying is effected with the mixture stored in aerated piles.

8. A process according to any of claims 1 to 7, wherein, in the second step, the mixture is composted such that the temperature of the mass of material is maintained at 40°C or above for a period of at least 5 days, with a temperature of at least 55°C being achieved for a minimum of four hours within that period.

9. A process according to any of claims 1 to 8, wherein a pH of at least 10.5 is maintained for a period of at least 7 days.

10. A method for conditioning and/or fertilising land by applying thereto the product obtained by a process according to any of claims 1 to 9.

Patents Act 1977
E: miner's report to the Comptroller under Section 17 (The Search Report) - 16 -

Application number

GB 9306059.8

Relevant Technical fields

(i) UK Cl (Edition L) C1C C1B (BBG)

(ii) Int Cl (Edition 5) C02F C05F

Databases (see over)

(i) UK Patent Office

(ii) ONLINE DATABASE: WPI

Search Examiner

R HONEYWOOD

Date of Search

24 AUGUST 1993

Documents considered relevant following a search in respect of claims 1-10

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
X	GB 2037268 A (WILHELM ROEDIGER GMBH)	1 at least
X	GB 1600901 (NATUMIX FERTILISERS LTD)	1 at least
X	GB 1560467 (MANCHAK)	1 at least
X	GB 1123833 (MCNEIL)	1 at least
X	GB 305346 (HADFIELD)	1 at least
X	EP 0283153 A1 (N-VIRO ENERGY SYSTEMS LTD)	1 at least
X	US 5043081 (AGENCE NATIONALE POUR LA RECUPERATION ET L' ELIMATION DES DECHETS)	1 at least
X	US 5013458 (R D P COMPANY)	1 at least
X	US 4997572 (WILLOW TECHNOLOGY INC)	1 at least

Category	Identity of document and relevant passages	Relevant to claim(s)
	-17-	

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family, corresponding document.

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